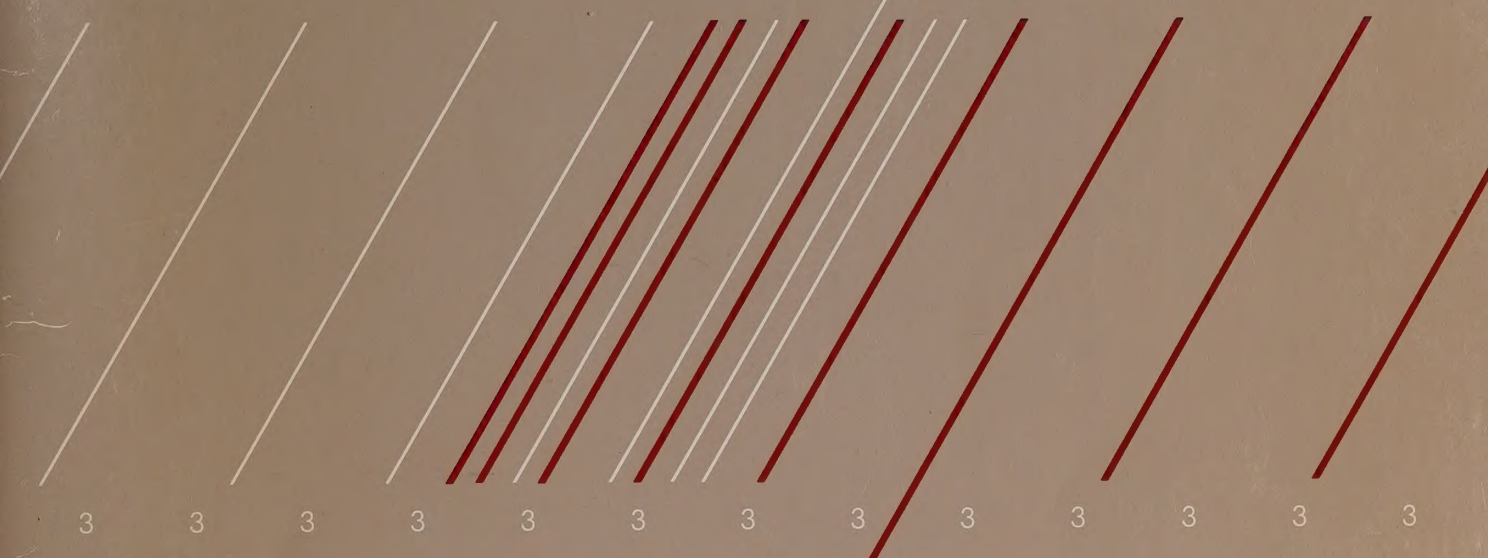
The Ontario
Task Force on
Employment and
New Technology



Emerging New Technology 1985-95: Framework for a Survey of Firms

An Appendix to the Final Report

ONTARIO TASK FORCE ON EMPLOYMENT AND NEW TECHNOLOGY

Co-Chairmen of the Task Force

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ROBERT WHITE
Director for Canada, United Auto Workers Union

Members of the Task Force

RALPH BARFORD
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President, Ontario Division, Canadian Union of Public Employees

FRED POMEROY
President, Communications Workers of Canada

THOMAS ARMSTRONG
Deputy Minister, Ontario Ministry of Labour

BENSON WILSON
Chairman, Ontario Manpower Commission

Staff

Richard Brown, Research Director

Stanley But

Hildegard Martens

EMERGING NEW TECHNOLOGY, 1985-1995: FRAMEWORK FOR A SURVEY OF FIRMS

This Appendix contains a report prepared for the Ontario Task Force on Employment and New Technology. The topic was approved in advance by the Task Force. At the conclusion of the study, the Task Force had the opportunity to review the report but its release does not necessarily imply endorsement of the results by the Task Force or its individual members.

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FOREWORD

The Ontario Task Force on Employment and New Technology, a joint labour-management group, was established in May 1984 "to consider and report on the manpower and employment implications of new technologies as the same may be introduced and applied in Ontario during the next decade and the extent and nature thereof."

To inform its discussions, the Task Force established a research agenda designed to gather information on employment and technological change from a wide variety of sources. The research agenda contained projects which gathered information of a historical nature, and projects with a future orientation which were designed to gather information describing likely occupational and employment implications associated with technological change in the 1985-1995 period.

The Appendices to the Final Report of the Ontario Task Force on Employment and New Technology contain reports of these research projects. A complete list of these Appendices may be found at the rear of this document. This particular Appendix describes work which was completed early in the Task Force's research program, and which established the methodology for a subsequent survey of technological change in firms and industries.

The study of technological change is still in its infancy, and there is no generally accepted methodology for determining employment-related consequences. This report may therefore be of interest not only for the particular information which it contains but also for the methodology which it describes.

Dr. Richard L.E. Brown, P.Eng.
Research Director

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The work presented in this report reflects earlier research activities of the Ontario Manpower Commission, whose technical support and assistance is most warmly acknowledged.

The valuable contributions made by Stanley But and Michael Doucette in the preparation of this report are particularly acknowledged.

HIGHLIGHTS

This report identifies new technologies that may have significant employment impacts over the 1985-1995 period and their points of intersection with major occupational groups and industry sectors in Ontario. This report prepares a framework for a survey of firms aimed at identifying current and future technological, occupational and employment changes.

Ten major groups of new technology are examined in this study, and are categorized into two stages: the research and development stage, and the commercial application stage.

Four major groups of emerging new technology have been identified as having significant potential employment impacts in the next ten years. These are:

- o Office Automation Technology
- o Telecommunications Technology
- o Computer-Based Technology
- o Advanced Manufacturing Technology

Eight major occupational groups are identified as likely to be particularly affected by the introduction and adoption of these groups of new technology. These are:

- o Managerial, Administrative and related Occupations
- o Natural Sciences, Engineering and Mathematics Occupations
- o Clerical and related Occupations
- o Sales Occupations
- o Processing Occupations
- o Machining and related Occupations
- o Product Fabricating, Assembling and Repairing Occupations
- o Materials Handling and related Occupations

The industry sectors that are major employers of each of these occupational groups are also identified. These are:

- o Primary Metal and Metal Fabricating
- o Motor Vehicles and Parts
- o Machining and Other Transportation Equipment
- o Electrical Products
- o Chemical, Rubber and Petroleum
- o Communication
- o Trade
- o Finance, Insurance and Real Estate
- o Community, Business and Personal Services
- o Public Administration

Within these industry sectors, industries at a 3-digit Standard Industrial Classification level are identified which are important employers of the identified occupational groups.

The identification of technologies, occupations and industries provides the framework for a survey of firms regarding the employment impacts of technological change.

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1.0 INTRODUCTION

A number of important new technologies are expected to be adopted in the workplaces of Ontario over the next ten years. Dramatic advances have already been made in the development of a number of new technologies, and, in an increasingly competitive world, it is expected that the application of advanced technologies will have a significant impact on future economic growth and opportunity.

The Ontario Task Force on Employment and New Technology, a joint labour-management group, has been established to examine the nature and extent of the manpower and employment implications of new technologies as they are introduced and applied in Ontario over the next ten years.

As the Task Force developed its research design, it became apparent that the complexity of the problem, and the uncertainties associated with the future, required a unique research effort. Consequently, the Task Force initiated several research projects each of which addressed different but related aspects of the overall issue.

Each research project provided valuable data on its own, as well as results which would be of value in developing an overall employment picture for the 1985-1995 period. There are a number of different approaches which can be taken for gathering information regarding future employment levels. However, of critical importance is the the gathering of up-to-date information from the field, at the firm level, about current technological, employment and manpower trends that are occurring, and which are likely to occur in the future. Consequently, an important part of the Task Force's research was a major survey of firms across Ontario to identify these trends and gather other data from the field which would help the Task Force answer its primary research question.

In setting out to conduct a survey in such a complex subject area, there is a need to strategically orient the direction and application of resources. It is, for example, clearly impractical to survey all firms. Further, in order to elicit useful results there is a need to be reasonably specific about what particular technologies information is being sought, and what sort of employment-related

impacts are being examined. This report provides a framework for the orientation of the field survey toward certain technologies, occupations, and industries.

1.1 Purpose

This report describes the rationale behind the selection of technologies, occupational groups and particular industries on which the Task Force focused its field survey research.

This report has three main objectives. First, to indentify those technologies with significant potential employment impacts that can reasonably be expected to occur over the next ten years. Second, to identify the major occupational groups most likely to be affected. Third, to identify those industries which contain the largest shares of these occupational groups.

1.2 Methodology

In developing its research design the Task Force faced a number of challenges. First, there is no generally accepted methodology for determining the employment impacts of technological change and therefore the Task Force's research represents a ground-breaking exercise. Second, it is very difficult to separate the effects of technological change from other factors which may affect employment. Third, the resources the Task Force had available to conduct field research to examine this problem were finite, and in order to yield useful results would need to be focused.

For the purposes of this study, we are only concerned with technologies that are expected to have significant potential employment impacts over the 1985-1995 period. Emerging new technologies are defined to include new or modified products, techniques and processes, and to include technologies that are rapidly diffusing and/or improving, as well as other technologies that are not fully developed but can reasonably be expected to be widely commercially applicable and therefore have significant potential employment impacts over the next ten years.

Groups of emerging technologies were examined to establish, on the basis of informed judgement, areas in which the most significant employment effects were likely to occur during the 1985-1995 period. After identifying groups of emerging new technologies, major occupational groups were identified that most likely would be affected, both positively and negatively, by the introduction and adoption of these technologies.

Finally, using data on the distribution of these occupational groups by industry, those industry sectors and particular industries which employ the largest shares of these occupational groups were established. This identification was then used to develop the research design for the Task Force's field research.

2.0 EMERGING NEW TECHNOLOGY

A number of groups of emerging new technologies have been identified as having significant potential future employment impacts. These groups are in different stages of their technical and commercial development, and may therefore be associated with employment impacts of different natures which may occur at different future times.

The development, application and diffusion of any new technology can be categorized into five stages. First is the research and development phase. When economic and technical feasibility have been established, a new technology moves into the commercial application stage. As market acceptance occurs, a new technology moves into a rapid growth stage. As the rate of growth for a particular new product or process begins to decline and the market becomes saturated, the market shifts from a growth to replacement market, and a technology can be said to be in the mature stage. Finally, as new technologies are introduced which are substituted for an existing product or process, the previous technology moves into the decline stage.

The rates at which any technology is likely to move through these stages are difficult to estimate. In general, there is often a tendency to over-estimate the speed at which a new technology is likely to be adopted in the short run. This is due in part to the over-optimistic selling by some of the importance of particular technologies, and in part due to an unrealistic underestimation of the barriers to their commercial adoption. On the other hand, history suggests there is a tendency to underestimate the magnitude of the impacts which occur in the long run associated with technological change.

The distinctions between stages in the development, application and diffusion of any technology are only broad, and for any specific product or process may be highly subjective, but are conceptually important since the occupational implications of any technology change as it moves through this product/innovation life cycle. For example, technologies at the early stage of development probably will require highly skilled and qualified scientific or technical manpower. But as new technologies are commercially adopted their manpower impacts expand to include a larger number of occupational groups.

While research and development is proceeding in all the identified technology groups, some have already led to important new products or processes which are widely commercially applied, and which, over the next decade, are expected to have significant economic impact. Table 1 characterizes ten major emerging new technologies into the research and development and commercial application stages. For those technologies which are at present in the research and development phase, an estimate is made as to when these new technologies should begin to become widely commercially available in some form. This estimate is only used for the purpose of assessing when significant potential employment and manpower implications may become apparent, and therefore in what areas the Task Force should focus its field research.

2.1 Major Technology Groups with Significant Potential Employment Impacts Over the Next Ten Years

Of the ten groups of new and emerging technologies, our analysis suggests that four major groups are likely to diffuse rapidly through the workplaces of Ontario over the next ten years. These are:

- o Office automation technology
- o Telecommunications technology
- o Computer-based technology
- o Advanced manufacturing technology

This identification, although described in slightly different terms, has been made by many other obsevers. For example, Christopher Freeman and Luc Soete, of the Science Policy Research Unit, University of Sussex, state in a paper prepared for the Organization for Economic Cooperation and Development:

> ...our research, like that of similar work elsewhere, points unambiguously to the conclusion that the dominant new technological paradigm is associated with the combination of micro-electronics, computers, telecommunications and information technologies.

TABLE 1

CATEGORIZATION OF NEW TECHNOLOGIES

Technology	R&D Stage	Commercial Application Stage 1985-1995
1. Office Automation Technology		
Word Processor		X
Fully Integrated Workstation		X
Microcomputer		X
Local Area Network		X
Electronic Filing Systems		X
Internal Data Base Management Systems		X
External Data Base Services		X
2. Telecommunications Technology		
Video Conferencing		X
Private Automate Branch Exchange		X
Videotex		X
Fibre Optics		X
Electronic Mail		X
Dedicated Head Office/Plant or Customer Computer Links	X	X
Facsimile Transmission		X
Dedicated Satellite Systems		X
3. Computer-Based Technology		
Very Large Scale Integrated Circuits		X
Supercomputer	X	X
Artificial Intelligence/Expert Systems	X	X
Fourth Generation (Natural) Programming Languages	X	X
Voice Synthesis/Recognition	X	
Electronic Funds Transfer System		X
Customer Sales and Service Systems		X
Point-of-Sale Scanning Systems		X
Automated Teller Machines		X
Smart Cards	X	X
Computer Decision Support Systems		X
4. Advanced Manufacturing Technology		
Computer-Aided Design		X
Computer-Aided Manufacturing		X
CAD/CAM Integration		X
Computerized Numerically Controlled Machine Tools		X
Automated Storage and Retrieval		X
Manufacturing resource planning		X
Computer-Aided Inspection and Testing		X

Table 1 (Cont'd)

	Technology	R&D Stage	Commercial Application Stage 1985-1995
4.	Advanced Manufacturing Technology (Cont'd)		
	Flexible Manufacturing Technologies		X
	Automated Shop Floor Data Collection		X
	Computerized Process Control Systems		X
	Robotics		X
	Computerized Decision Support Systems		X
	Computerized Order Entry Inventory Control		X
	Computer-Integrated Manufacturing		X
5.	Biotechnology		
	Genetic Engineering	X	
	Enzyme and Enzyme Systems	X	
	Cell Fusion		X
	Plant Cell Culture	X	
	Process and Systems Engineering	X	
6.	New Materials Technology		
	Powder Metallurgy		X
	Composites		X
	New High-Strength Ceramics	X	X
7.	Laser Technology		
	Laser Imaging		X
	Laser Cutting/Welding/Drilling		X
	Optical Data Storage	X	X
	Opto-Electronics	X	
	Medical Applications		X
8.	Space Technology		
	Satellites		X
	Aerospace Equipment	X	
9.	Energy Technology		
	Solar	X	
	Watermill	X	
	Windmill	X	
	Power Canals	X	
	Ocean Thermal Energy Conversion	X	
	Advanced Energy Storage Batteries	X	
10.	Ocean Technology		
	Deep Sea Mining	X	

Although other groups of new technologies may be commercially applicable in the next ten years they are unlikely to have as significant employment impacts within this time period. For example, many of the applications of biotechnology are in product or process innovations which are concentrated in the medical and health field, and although they may have significant economic impacts for certain industries and the general quality of life, they are unlikely to affect the direct delivery of services to individuals where most of the employment in the health industry is located. Enzyme and enzyme systems and genetic engineering could have significant impacts in a number of process industries such as pharmaceuticals, food and agriculture. However, these industries are already highly capital intensive and are not substantial employers overall.

As well, new materials technologies, particularly in the area of high-strength ceramics, have the technical promise of providing important commercial breakthroughs in the not too distant future. However, on the basis of what we know at present, it appears unlikely that these developments will have significant employment impacts in the 1985-1995 period.

Innovations in microelectronics technology, which have driven down costs and increased performance to such a great extent over the last ten years, are a common factor to the identified four major new technology groups. The impact on employment resulting from the development and manufacturing of these major new technologies needs to be examined, as well as the the impact on employment resulting from the adoption of these new technologies within existing products and other industries.

The following sections will examine these four major groups of new technologies and identify in greater detail the types of technologies that fall within these groups. From this detailed identification, we will continue to identify the major occupational groups which appear most likely to be affected by the introduction and adoption of these new technologies, and to identify the industries containing significant shares of employment for these occupational groups.

TABLE 2

OFFICE AUTOMATION TECHNOLOGY

Technology	Selected Applications
Word Processor	Preparation, modification and printing of written documents
Microcomputer/Personal Computer	Data analysis, manipulation and storage, graphics, word processing
Electronic Filing Systems	Large-scale document storage
Fully Integrated Work Station	Multi-function word and data processing, microcomputer,and voice and data terminal
Local Area Network	Linkage of microcomputers so that data and software can be communicated
Internal Data Base Management Systems	Organization and collection of data for various management purposes
External Data Base Services	Provision of information and data services

2.1.1 Office Automation Technology

Office automation technology includes a wide range of new technologies and products that will be primarily used in the office or other administrative operations. Most of these technologies are microelectronics or computer-based and many have some communication capabilities which make the traditional distinction between computer, office and telecommunications technologies increasingly blurred.

The major office automation technologies include standalone devices such as word processors, electronic typewriters, and microcomputers which do not have any communications capabilities. Local area networks and other communications software systems allow a number of office devices to share information and data and enable the provision of services such as electronic mail or electronic filing. More complex office automation systems use fully integrated workstations which are multifunction devices that can perform word processing, data manipulation, and voice and data communications. There are barriers to the rapid development and widespread adoption of the fully integrated office concept, such as the lack of a single office automation standard which would allow communications between machines produced by different manufacturers. However, these sorts of impediments are expected to be progressively reduced over the next ten years.

Given the growing importance of information to the effective management, administration and operation of most organizations, the number and significance of information systems is expected to increase during the next ten years. Internal data base management systems have been used in some large organizations for a number of years, and with powerful and inexpensive microcomputer systems now available, they can be expected to diffuse rapidly through many smaller sized organizations. Increasingly, data base management systems will be integrated with other operational systems, for example to capture operational or shop floor information which can then be used directly for other management activities.

A large number of external data base services are commercially available at present. These include electronic versions of current and past periodicals and newspapers, current and historical stock market quotations, financial, scientific and bibliographic data bases. Many of these data bases can be accessed using a personal computer, microcomputer, or a computer terminal equipped with a modem, or through larger timesharing computer systems, or through a library. There are a number of commercial operators of database services, including computer service bureaus, common carriers, and information divisions of periodical publishers who act as information brokers and provide access to a range of database services.

2.1.2 Telecommunications Technology

A number of important telecommunications technologies have been identified which include: private automated branch exchanges, electronic mail, voice mail, facsimile links, dedicated satellite or microwave systems, video conferencing, fibre optics, and dedicated head office/plant or head office/customer computer linkages. As well, technologies in other areas will increasingly have information handling and telecommunications capabilities built in.

Private automated branch exchanges are switching systems that plug into the telephone system and switch calls throughout an organization's offices. Since 1979 when telephone inter-connection was allowed by the Canadian federal regulatory authority, a growing number of sophisticated branch exchanges and telephone systems have become available that allow users to tailor hardware to their specific requirements. Private automated branch exchanges allow organizations to reduce costs, monitor long distance charges, and may have sophisticated call forwarding, voice mail or data communications facilities. Most exchanges sold in the future will convert the analog sound waves produced by the human voice, to the digital, on-off pulses used by computers, and other electronic equipment.

Electronic mail systems can be operated on some types of private automated branch exchange systems, computer-based management information systems, and timesharing or local area network systems so as to distribute mail,

memos, reports or data electronically throughout an organization. Until a common electronic mail standard is developed, firms wishing to communicate externally will normally have to use the commercial electronic mail systems being offered by telecommunications carriers between compatible communicating word processors or microcomputers.

Facsimile transmission allows for copies of written documents to be transmitted over existing telecommunications facilities. Facimile transmission equipment translates the written form of a document into a series of electronic signals which are transmitted to another similar facsimile device which then prints the document. Current digital-based facsimile technology with built-in microprocessors allows facimile machines produced by different manufacturers to communicate and produce copies of very high quality.

Dedicated satellite or microwave systems may be used by large organizations to provide communications between a large number of regionally dispersed offices or plants. At present, the only satellite or microwave systems operating in Canada are those operated by the telecommunications common carriers from which users must lease their services, and there are no private dedicated systems. However, there are several private dedicated telecommunications networks operating in the United States, and while regulatory uncertainties may delay the introduction of similar services in Canada, the interest of some large organizations in moving in this direction is clear.

Video conferencing allows meetings to be held using a dedicated telecommunications link from specially equipped facilities between remote locations. Video conferencing can use a firm's own facilities, or those offered by a telecommunications carrier, and allows video or partial video, audio and data communications.

Fibre optics are thin flexible strands of extremely pure glass that are used to carry telecommuniccations signals encoded as pulses of light. Twelve strands of optical fibres, about the same thickness of a human hair can carry as much information as two copper cables with 4,400 lines, each measuring three inches in diameter. Since fibre optics can carry very large volumes of information in a cost effective manner, in many applications they are replacing existing copper wire or co-axial cable in telecommunications systems. Fibre optic systems use a

TABLE 3

TELECOMMUNICATIONS TECHNOLOGY

Technology	Selected Applications
Private Automated Branch Exchanges	Telephone switching, call forwarding, call monitoring, cost tracing, voice mail, call forwarding
Electronic Mail	Inter-office mail, memos, documents or reports
Video Conferencing	Remote meetings include full or partial video link, audio and data transmission
Fibre Optics	Broadband, high capacity telecommunications links, secure telecommunications facilities, military applications
Head-Office/Plant Computer Lines	Exchange of data, electronic mail, reports, memos between regionally dispersed operations
Head-Office/Customer Computer Links	Sales ordering, inventory monitoring, sales trends analysis
Videotex (Telidon)	Transmission of text or graphic information over telephone lines to normal television set equiped with special decoder
Facsimile Transmission	Transmission of written documents
Dedicated Satellite Systems	Long-distance communication between regionally-dispensed offices

digital based technology, and small lasers to transmit signals. Fibre optics have a much higher information carrying capacity than existing transmission mechanisms. They also have several other advantages. They offer better security than traditional copper wire or co-axial cable systems, are not subject to electromagnetic interference, and are much smaller and therefore can be used in areas where space is a constraint. The introduction of fibre optics in Ontario is likely to be gradual and will be done as existing facilities need to be replaced or as new trunk or feeder lines are constructed.

Dedicated head-office/plant or head-office/customer computer links allow operational information or data, customer orders, and inventory information to be exchanged directly. Dedicated head-office/customer computer links would reduce the need for routine sales ordering and allow production to be matched more closely to customer inventory and sales changes. With the advent of cheap and even portable computer terminals, a wide variety of information-related activities are likely to be affected.

Videotex, or Telidon, as it is known in Canada, is a communications protocol which allows textual or graphic information be transmitted between a computer and a modified domestic television set equiped with a special decoder using normal telephone lines. Initially, when this technology was introduced it was expected to diffuse very rapidly, but due to a number of factors these initial expectations have not yet materialized.

2.1.3 Computer-Based Technology

The computer-based technology group includes those major new types of computer hardware and software likely to be introduced in the next ten years, as well as applications of computer technology in other functional areas.

Computer technologies are applicable to all industries. In order to respond to changing market needs, the information requirements of modern management techniques, and to reduce costs, a number of related computer technologies are expected to diffuse widely over the next decade. The type of applications within specific industries will vary depending on the particular business activities.

A number of major hardware and software innovations are expected to begin to have significant employment impacts over the next ten years. These include very large scale integrated circuits, supercomputers, artificial intelligence and expert systems, and fourth generation programming languages. Very large scale integrated circuit technology will replace existing microprocessor and memory components in electronic equipment and computers. This technology, and the replacement of silicon with gallium arsenide, should allow improvements in cost and performance for microelectronics to continue for some time.

Because of their high cost, supercomputers have only limited application in areas which require very high speed, large scale data analysis. Existing application areas include long term weather forecasting, scientific data analysis, and military intelligence.

Artificial intelligence and expert systems include a wide range of technologies. The objective of artificial intelligence is to allow computers to simulate human decision making. Although artificial intelligence is primarily in the research and development phase, a limited number of applications have already been developed in areas such as pattern recognition and visual processing which can be used for controlling robots or other advanced manufacturing tools.

Expert systems combine the knowledge and experience of a number of experts into a series of decision rules for tackling a problem. Expert systems are presently being used in diagnostic systems in medicine, equipment maintenance, and in mineral exploration, accounting, and engineering. Commercial expert systems are expected to become increasingly available in areas such as engineering and design, order and inventory control, financial services, insurance underwriting, and banking. It is expected that by the mid 1990's most computer based management information systems, customer support and service systems, order and inventory planning and control systems, computer aided design or computer aided manufacturing systems, will have some expert system capabilities built in.

TABLE 4

COMPUTER-BASED TECHNOLOGY

Technology	Selected Applications
Very Large Scale Integrated Circuits	Microprocessor and Memory Components
Supercomputer	Long term weather forecasting, large scale data analysis, cryptography
Artificial Intelligence	Robotics, Advanced Machine Tools, Pattern Recognition, Computer-Aided Design/Manufacturing, Computer-Aided Engineering
Expert Systems	Diagnostic and Decision Support Systems in Mining, Medicine, Law, Accounting, Engineering
Fourth Generation (Natural) Programming Languages	All Present Software Applications
Voice Synthesis/Recognition	Selected Input and Output Applications
Point-of-Sale Scanning Equipment	Retail Sales Data Input, Monitoring Inventory
Electronic Funds Transfer System	Finance, Banking and Retailing
"Smart" Cards	Retailing, Banking
Automated Teller Machines	Banking, Retailing
Computer Decision Support Systems	All Management Areas
Customer Sales and Service Systems	Systems for delivering information Services directly to customer

Fourth generation or natural programming languages are another significant innovation in the area of computer technology. The objective of fourth generation programming langauges is to develop computer programming languages that resemble existing natural languages, which would make computers easier to program.

Voice synthesis and recognition systems may be used to replace existing means of getting information in or out of a computer system, such as keyboards, terminals, keypads, light emitting diodes, light pens, and printers. Voice synthesis and recognition may be applied in products such as automobiles, appliances, typewriters and word processors, personal computers and certain military applications.

A wide range of computer-based customer sales and service technologies that are being introduced also have significant potential employment impacts. These include systems for making and recording customer sales, orders, and work in progress, and systems for delivering services directly to consumers. These technologies vary from industry to industry, and include point-of-sale scanning equipment, electronics funds transfer systems, "smart" credit cards with built in microprocessors which store transaction, account, and billing information, computerized financial services, insurance and banking systems.

Computer decision support systems are applicable in a wide range of management information systems or microcomputer-based software packages. They provide data and monitor information used by management in sales planning, inventory control, accounting, and finance. Computer decision support systems can be large-scale custom-produced software packages, or included in either custom or turn-key management information systems, or included as part of commercial software packages.

2.1.4 Advanced Manufacturing Technology

Advanced manufacturing technology includes a number of design, process, materials handling, programmable automation, planning, and control technologies. These new technologies affect production operations, and "upstream" and "downstream" activities such as planning, design and engineering,

customer service and inventory control. The common element in advanced manufacturing technologies that makes them different from traditional manufacturing tools is their use of computer or microelectronics technologies to store, manipulate, and sometimes communicate programs or data to other activities in the factory. Increasingly, advanced manufacturing technologies will be used to capture data to be used for other management uses such as just-in-time inventory systems, work scheduling and planning systems.

A number of advanced materials-handling technologies have also been identified as important within the maufacturing sector. These include automatic conveyor or vehicle systems, and computer-controlled conveyor or vehicle systems where the route, destination or speed can be easily changed. Automated warehouses and automated part carousels increase the ease by which parts can be located and reduce overall warehouse space requirements.

Robotics is another technology that has been identified as having potential employment impacts over the next ten years. There are three main parts to a typical industrial robot, consisting of a controller, manipulator, and end-effector. The controller is the hardware and software used to control the motions of the robot, and through which its instructions are programmed by the operator. This can be done through a large central computer or a small microprocessor built into the machine. The manipulator consists of a base, an actuator mechanism, and an arm which is equipped with a number of joints allowing it limited movement. The end-effector is the tool the robot uses to perform a specific task, and can include spray guns, grippers, bottle lifters, welding guns, or vacumn lifters.

Robots can be used in a number of processing or fabricating operations, including such hazardous or tedious activities as spray painting, spot welding, or in operations processing dangerous materials. Robotics can also be used in a number of important materials-handling applications, which include machine loading and unloading, pick-and-place operations, and palletization. Robotics provide reliability and improved product quality in situations where repetitive tasks are performed. They also can replace human workers in performing dangerous or unhealthy work tasks. Industrial robots which are currently available, and those which are likely to be available over the next decade,

neither resemble humans, nor have more than a fraction of the dexterity, flexibility or intelligence of humans. It is expected that signifigant improvements in robot capabilities will need to be made before the employment impacts resulting from their adoption will reach large proportions.

A number of process planning, resource planning, inventory control, and quality assurance systems are also being introduced into manufacturing. These advanced technologies perform operational planning functions, reduce costly inventory, and work-in-progress. Advanced quality control systems use statistical quality control methods to raise product quality. Significantly, the adoption of these technologies can proceed with relatively modest levels of capital investment and without necessarily changing existing production facilities.

Advanced manufacturing technologies are of particular importance in discrete batch-production manufacturing industries. Advanced manufacturing technologies have the primary advantages of increasing the ease of design changes, decreasing re-tooling time, reducing material wastage, production time, and work in progress. Advanced manufacturing technologies are particularly useful in small scale batch production, and increase the range of products which can be produced economically on the same equipment. They are ideally suited to Ontario manufacturing industries which serve a small domestic market, have short production runs, and high re-tooling costs when switching from one product to another.

In process industries, such as oil, petro-chemicals, plastics and cement manufacturing, although advanced process control and monitoring technologies will be increasingly important, they will most likely not have as large overall employment impacts since these industries are already highly automated.

Although manufacturing activities vary widely, in general the production process typically includes design, engineering, materials handling, fabrication, finishing, assembly, quality assurance, and inventory control.

TABLE 5

ADVANCED MANUFACTURING TECHNOLOGY

Technology	Selected Applications
Computer-Aided Design	Design, drafting, layout of manufactured products, piping, electrical or electronic circuits
Computer-Aided Manufacturing	Systems for storing and transmitting instructions between computer systems and various grinding, milling, boring, and cutting tools
CAD/CAM Integration	Combines functions of both technologies above so that data from CAD can be directly transmitted to machine tool instructions
Computerized Numerically-Controlled Machine Tools	Machine tools re-programmable locally or remotely
Robotics	Pick and place, machine loading/ unloading spot welding, spray painting, palletization, assembly, fabrication
Manufacturing Resource Planning	Resource planning, ordering, monitoring and control
Automated Shop Floor Data Collection Systems	Collect data from production for other management purposes
Computerized Decision Support Systems	Assists management production, planning and design decision making
Computerized Order Entry Inventory Control	Uses sale orders to intitate work orders, and monitor inventory and work in progress
Computer-Aided Inspection and Testing	Inspection and statistical quality control in all manufacturing areas
Computer-Integrated Manufacturing	Fully integrated advanced systems with CAD, CAM, and many have CAE, shop floor data collection, inventory control, resource planning faculties
Flexible Manufacturing Technologies	Small to medium scale batch production, allows rapid re-tooling and multi-product production on same production line - customized on off products

Table 5 (Cont'd)

Technology	Selected Applications
Computerized Process Control Systems	Controls energy, temperature and cycle times in process operations in oil and petrochemical processing - plastic, cement and pharmaceutical manufacturing
Automated Storage and Retrieval Systems	Inventory storage
Automated Conveyor/Vehicle Systems	Materials handling
Computer-Controlled Conveyor/ Vehicles	Materials handling

Computer-aided design in its simplest form is an electronic drafting board which can be used to store frequently used shapes and allow draftspersons or engineers to rotate, zoom-in, alter, or copy a design. In more complex systems, computer-aided design systems are linked with computer-aided engineering systems which allow engineers to model the physical performance of a part, perform stress analysis, or other simulated testing. Computer-aided manufacturing systems translate design data into machine tool instructions which are used to produce a part.

CAD/CAM integration is a bridging technology that links together computer-aided design and computer-aided manufacturing systems. In more complex computer integrated manufacturing systems, computer-aided design, manufacturing, and testing functions are integrated together.

Advanced manufacturing technologies are expected to be applied in a number of machining, fabrication and assembly operations, including those which use numerically-controlled machine tools, computer-controlled machine tools, and robotics. The primary difference between the older numerically-controlled machine tools and computer-controlled machine tools is that the latter can be directly programmed from a computer-aided manufacturing system and may have a built in microprocessor. This allows computer-controlled tools to be integrated with other manufacturing systems and reduces the downtime spent when retooling or switching product lines.

2.2 Converging Trends In Technological Development

There are a number of important trends in technological development that are affecting all of the major technology groups identified. The definition and specifications of each technology are evolving as they move through their product life cycle. As new technologies become established, new applications will increasingly be built into a previously defined technology. For instance, as design and engineering technologies evolve, the distinctions between computer-aided design, computer-aided manufacturing, computer-aided engineering, and computer-integrated manufacturing will probably tend to reduce.

As a result, there will be a strong convergence trend in all technologies using microelectronics, particularly in computer-based technology, office automation technology, and telecommunications technology. Increasingly, existing analog-based technology will be replaced with digital-based technology in a wide range of office devices, telephone equipment, private automated branch exchanges and office automation systems. As this takes place, the technical difference between voice and computer data, and various other types of information and data will disappear, accelerating convergence trends.

As this process of evolution develops, the distinctions between these major new technology groups will continue to blur and there will be a tendency toward the integration and linking of various technologies. Increasingly, communications capabilities will be built into a wide range of office devices, manufacturing tools, personal computers, workstations and computer systems. This will facilitate the sharing of information and data within and between organizations, and in the long run has the potential to significantly affect the traditional structure and management of organizations. It is to be expected that this would be reflected in changes of the occupational employment patterns across industries.

3.0 NEW TECHNOLOGY AND OCCUPATIONAL GROUPS

3.1 Introduction

The most immediate employment-related effect resulting from technological change in organizations is to change the work available to people - that is the number, type and mix of work tasks which need to be done. The relationship between the introduction of new technology and changes in work is complex. There are changes in the extent and nature of work that directly result from the introduction of new technology which are relatively easy to identify. However, there are also work changes of an indirect nature, which may be substantial, yet difficult to completely identify, and even more difficult to quantify. The introduction of new technology may facilitate organizational changes, or changes in management practices that are occurring for other reasons, but are associated with the introduction of technological change.

Given the importance of the institution of work in our society, one of the most serious consequence of technological change is job loss, or the permanent reduction in demand for a specific occupational group with a certain set of skills. The magnitude of the impact on affected individuals will depend on the demand for these skills and the overall level of demand in the economy.

Technological change may also be accompanied by an increase in the overall number of work tasks required in the economy. Historically, this has been the case. New jobs may be associated with the creation of new technology and with its production and adoption. While it is true that the adoption of new technology may result in the displacement of some work tasks that might otherwise have been available, new work tasks may also be created as the result of the adoption of new technologies, either in the same firm or industry or elsewhere. If new technology allows costs to be lowered or stabilized, or permit product quality to be raised, it is possible that this may expand demand for a firm's output, causing production to increase and increasing the number of work tasks available. New technology may also create spinoffs in firms or industries associated with the production, support and maintenance of new technology. In addition, new technology may allow the making of new products not previously possible, which in turn, creates additional work tasks.

As new technology affects the type and mix of work tasks needing to be done, it also affects the skill requirements associated with these tasks. The creation of increasingly complex technology requires more sophisticated skills. However, in those organizations adopting new technology the skill changes are less obvious. Sometimes new work tasks will require more sophisticated or a greater range of skills. However, sometimes the reverse will be true and the adoption of new technology will reduce or eliminate the need for certain skills. It is possible that these two trends may occur simultaneously in the same organization at different organizational levels or affecting different occupational groups.

Over the long run, the changing nature of work tasks will result in measurable occupational trends.

3.2 Technological Change and Occupational Groups

The employment-related effects resulting from the introduction and adoption of new technology is likely to vary significantly for different occupational groups. Based on an assessment of the nature of the identified technologies, their stage of development and application, the major occupational groups which appear most likely to be affected have been identified. The points of intersection of the four major groups of new technologies with major occupational groups are outlined in Table 6.

Since new technologies will affect how firms produce, manage, and manipulate information related to their day-to-day operations, this will affect the production and flow of information in organizations, and therefore will affect clerical, managerial or administrative occupations.

Since the demands of an increasingly competitive world market will likely require industries to produce more sophisticated products, the impact of technologies such as computer-aided design, computer-aided manufacturing and computer-aided engineering will likely affect both traditional blue collar occupations such as engineering technicians, machinists, and tool and die makers, as well as white collar occupations, such as senior and middle management, and engineering occupations. Robotics, numerically-controlled machines, and

TABLE 6

POTENTIAL IMPACTS OF MAJOR NEW TECHNOLOGIES ON OCCUPATIONAL GROUPS

Major Occupational Group	Computer-Based Technology	Office Automation Technology	Advanced Manufacturing Technology	Telecomm. Technology
Managerial/ Administrative	1	1	1	1
Natural Sciences	1	1	1	1
Social Sciences	2	3	3	3
Religion	3	3	3	3
Teaching	2	3	3	3
Medicine	2	3	3	3
Artistic	3	3	3	3
Clerical	1	1	3	2
Sales	1	1	3	2
Service	3	3	3	3
Farming	2	3	3	2
Fishing	3	3	3	3
Forestry	3	3	3	3
Mining	2	3	3	3
Processing	2	3	1	3
Machining	2	3	1	2
Fabricating	3	2	1	2
Construction	3	3	3	3
Transportation	2	3	3	3
Materials Handling	2	3	1	3
Other Crafts	3	3	3	3

1. Significant Impact
2. Some Impact
3. Slight or no Impact

computer-controlled machine tools are likely to affect a range of processing, machining, product fabricating and assembly occupations. Materials-handling occupations may be affected by the introduction of a range of new technologies including robotics, automated computer-controlled conveyors or vehicles, automated parts carousels, and just-in-time inventory systems.

Sales occupations are likely to be affected by the introduction of point-of-sale scanning equipment, customer/head-office computer links, and computerized order entry and inventory control technologies. This will likely affect retail and general merchandise sales staff and specialized technical sales occupations.

In summary, the four major new technologies identified earlier are likely to particularly affect the following occupational groups:

- o Managerial, Administrative and related Occupations
- o Natural Sciences, Engineering and Mathematics Occupations
- o Clerical and related Occupations
- o Sales Occupations
- o Processing Occupations
- o Machining and related Occupations
- o Product Fabricating, Assembling and Repairing Occupations
- o Materials Handling and related Occupations

These eight major occupational groups accounted for about 2.4 million workers in 1981, or nearly 60 percent of the Ontario workforce. Clerical, sales, processing, machining, product fabricating, assembling and repairing occupations together accounted for nearly 50 percent of the workforce in 1981; clerical workers alone accounted for almost 20 percent. (See Table 7 for a more detailed breakdown of employment by major occupational groups in Ontario in 1981, and Appendix A for definitions of major occupational groups used in this report.)

TABLE 7

ONTARIO'S EMPLOYMENT BY MAJOR OCCUPATIONAL GROUPS, 1981

Major Occupational Group	Number Employed (000)	Percentage of Total
Managerial/Administrative	314.4	7.5
Natural Sciences	160.8	3.9
Social Sciences	68.9	1.7
Religion	9.3	0.2
Teaching	166.8	4.0
Medicine	175.2	4.2
Artistic	51.3	1.2
Sports	10.2	0.2
Clerical	813.5	19.5
Sales	404.0	9.7
Service	466.0	11.2
Farming	145.6	3.5
Fishing	1.3	0.0
Forestry	10.2	0.2
Mining	17.4	0.4
Processing	151.6	3.6
Machining	137.2	3.3
Fabricating	364.7	8.7
Construction	222.7	5.3
Transportation	142.1	3.4
Materials Handling	92.1	2.2
Other Craft	55.0	1.3
Other Occupations	193.2	4.6
Ontario Total	4,173.5	100.0

Source: Statistics Canada, Census Data, 1971 definitions

4.0 NEW TECHNOLOGY AND INDUSTRY SECTORS

4.1 Introduction

The impact of technological change will vary significantly across industries. This is due to the nature of new technology expected to be introduced, and its relationship to the activities of particular industries.

In order to maximize the effectiveness of the Task Force's field research, it is desirable to focus attention upon particular industries where the employment-related effects of technological change are likely to be most significant.

This has been done by determining which industry sectors and which industries at a finer 3-digit SIC level, are major employers of the occupational groups identified earlier.

Table 8 identifies and rank orders the industry sectors which contain the five largest shares of the occupational groups identified. (See Appendix B for definitions of industry sectors used in this report.)

In aggregate, ten industry sectors contain the largest shares of employment of the eight major occupational groups. These are:

- Primary Metal and Metal Fabricating
- Motor Vehicles and Parts
- Machinery and other Transportation Equipment
- Electrical Products
- Chemical, Rubber and Petroleum
- Communication
- Trade
- Finance, Insurance and Real Estate
- Communities, Business and Personal Services
- Public Administration

TABLE 8

INDUSTRY SECTOR/OCCUPATIONAL GROUP INTERSECTIONS

Occupations	Mgm't and Admin	Nat. Sci.	Cleri-cal	Sales	Process-ing	Mach-ining	Fabri-cating	Mat'l Handl
Agri/Fishing								
Forestry								
Min/Fuel/Wells								
Other Mines								
Food/Tobacco				4	2			2
Text/Clothing					5		4	
Wood/Furniture								
Paper & Allied				5				
Pr. Metal/Fabr					1	1		3
Mtr. Veh./Parts						3	2	
Mach/Trans. Eq		5				2	5	
Electrical Prod		3				4	3	
Chem/Petroleum		4			3			5
Non-Metal. Min								
Other Manufact								
Construction	5					5		
Elec/Gas Util								
Transp. & Stor								4
Communication			5					
Trade	4		2	1	4		1	1
Finance/Insur	3		3	2				
Com/Bus. Serv	1	1	1	3				
Public Admin.	2	2	4					

This table identifies and rank orders the industry sectors with the five largest employment shares for each of the occupational groups shown.
Source: Statistics Canada, Census Data, 1971 Definitions

4.2 Technological Change and Industries

The ten identified industry sectors accounted for over 72 percent of all employment in Ontario in 1981. On its own, the Communities, Business and Personal Services sector represented nearly 30 percent of all employment in Ontario in 1981. Just over 16 percent of employment was in the Trade sector, while the Public Administration sector represented about 7 percent of total employment in Ontario in 1981. For a more detailed breakdown of Ontario's employment by industry see Table 9.

Since these industry sectors in some cases are very broad, and contain quite different types of industries at the 3-digit Standard Industrial Classification (SIC) level, a further selection of specific industries from within each industry sector is necessary. In general, 3-digit SIC code industries within these industry sectors were identified that were major employers of the occupational groups of particular interest.

In the Primary Metal and Metal Fabricating sector the following 3-digit SIC level industries were identified: Iron and Steel Mills (SIC 291); Metal Stamping, Pressing and Coating (SIC 304); Hardware, Tool and Cutlery Manufacturers (SIC 306); and Miscellaneous Metal Fabricating Industries (SIC 309). Together these industries accounted for about 60 percent of employment in this sector.

In the Machinery and Other Transportation Equipment sector the following industries were identified: Miscellaneous Machinery and Equipment Manufacturers (SIC 315); Office and Store Machinery Manufacturers (SIC 318); Communications Equipment Manufacturers (SIC 335); Aircraft and Aircraft Parts Manufacturers (SIC 321). Together these industries accounted for nearly three quarters of the employment in this sector in 1981.

In the Electrical Products sector, the Communications Equipment Manufacturers (SIC 335) industry was identified. This industry on its own contained 36 percent of the employment in this sector in 1981, and accounted for over half the employment growth in this sector over the 1971-1981 period.

TABLE 9

ONTARIO'S EMPLOYMENT, BY MAJOR INDUSTRY SECTORS, 1981

Number Industry sector	Employed (000)	Percentage Of Total
Agriculture/Fishing	135.5	3.2
Forestry	12.2	0.3
Mineral Fuel & Wells	1.7	0.0
Other Mines/Quarries	37.9	0.9
Food/Feed/Beverage/Tobacco	95.1	2.3
Textile/Clothing	66.8	1.6
Wood/Furniture	56.1	1.3
Paper/Allied Industries	110.0	2.6
Primary Metal/Metal Fab.	178.4	4.3
Motor Vehicles/Parts	94.3	2.3
Mach/Other Trans. Eq.	93.0	2.2
Electrical Products	83.2	2.0
Chem/Rubber/Petroleum	100.4	2.4
Non-Metallic Mineral	28.6	0.7
Other Manufacturing	61.1	1.5
Construction	222.1	5.3
Elec/Gas Utilities	51.4	1.2
Transportation/Storage	162.9	3.9
Communication	83.1	2.0
Trade	682.1	16.3
Finance/Insur/Real Estate	245.8	5.9
Comm/Bus. & Personal Services	1165.6	27.9
Public Administration	289.5	6.9
Other Industries	116.8	2.8
Ontario Total	4173.5	100.0

Source: Statistics Canada, Census Data, 1971 definitions

In the Chemical, Rubber and Petroleum sector, the Plastics Fabricating Industry (SIC 165) was identified. Although this industry only represents 22 percent of total employment in this sector, it contains nearly half the employment for this sector in the Machining and Fabricating occupational groups. The Plastics Fabricating industry on its own accounted for nearly 40 percent of the employment growth in the 1971-1981 period for this sector.

In the Communication sector, three industries were identified which made up over 81 percent of the total employment in this sector in 1981. The three industries include: Telephone Systems (SIC 544), which includes common carrier, other telephone system operators, and inter-connect firms; Telegraph and Cable Systems (SIC 545); and the Post Office (SIC 548).

In the Trade sector, two industries were identified: Retail Food Stores (SIC 631) and General Merchandising Stores (SIC 642), which together contained nearly 30 percent of total 1981 employment in this sector. The remainder of employment in this sector is scattered over a number of smaller industries, the largest of which made up less than 6 percent of total employment for this sector. The two identified industries together accounted for over 45 percent of the employment growth over the 1971-1981 period, and employed nearly 40 percent of the clerical workers, and 30 percent of the sales workers in this sector.

In the Finance, Insurance and Real Estate sector, Chartered Banks and Trust Companies (SIC 701), Life Insurance Companies and General Insurance Companies (SIC 721), and Insurance Brokers (SIC 723) were identified. Together, these three industries accounted for over three quarters of 1981 employment in this sector.

In the Communities, Business and Personal Services sector, two industries were identified: the Computer Services industry (SIC 855), and Management and Business Consultants (SIC 867). These two industries had the two highest compound annual growth rate of employment in this sector. Many of the other industries in this sector are characterized by the direct provision of services to persons, and where this human contact is integral to the quality of the service provided it was thought that these industries would not be as likely to be directly affected by technological change. (Note: Because of the significant contribution that this sector made to overall employment in the 1971-1981

period, the Task Force initiated a special survey of this sector. See Appendix 19.)

In the Public Administration sector, all three levels of government were selected. Over 85 percent of total employment in this sector was included in the Task Force's field research.

It was decided that the impact of technological change on employment in the Motor Vehicle and Parts sector would not be examined by the Task Force. Since this industry sector is the subject of a similar study being conducted by the Canada Employment and Immigration Commission and the Ontario Manpower Commission, it was decided not to duplicate work being done elsewhere.

In the Communication sector the Post-Office had been identified as an industry to be examined by the Task Force. Unfortunately, for practical reasons, the Task Force was unable to include this industry in its study.

4.3 Selected Occupational Groups and Technologies, and Industries

In the manufacturing sector, it was proposed that the field survey should focus on the following occupations: Managerial, Administrative and related occupations; Natural Sciences, Engineering and Mathematics occupations; Processing occupations; Machining and related occupations; Product Fabricating, Assembling and Repairing occupations; Materials-Handling and related occupations. In the service sector, the following occupations were identified as being important: Managerial, Administrative and related occupations; Natural Sciences, Engineering and Mathematics occupations; Clerical and related occupations; and Sales occupations.

Table 10 outlines the number of each identified occupational group in each 3-digit industry that was proposed for field survey research. It also indicates the share contained within these industries of the total employment across Ontario for each occupational group.

Appendix C contains the Terms of Reference for the survey of firms and industries which used the identification of technologies, occupations, and industries made in this report.

TABLE 10

EMPLOYED LABOUR FORCE BY SELECTED OCCUPATIONS AND INDUSTRIES, ONTARIO, 1981

Industry/Occupation	Manag. Admin.	Natural Science	Clerical	Sales	Proc.	Machine	Fab.	Material Handling	Other Occ.	Total Occ.
Iron and Steel (SIC 291)	2	3	5	0	15	6	6	5	9	50
Metal Fab. (SIC 304,306,309)	4	2	7	2	5	23	6	2	5	56
Machinery and Equip. (SIC 315)	4	0	7	2	1	12	8	1	6	42
Aircraft & Aircr Parts (SIC 321)	1	2	2	0	0	2	6	0	2	15
Communications Equip. (SIC 335)	3	5	5	1	1	2	11	0	2	30
Office/Store/Bus/Mach (SIC 318)	2	3	3	1	0	0	3	0	0	12
Plastics Processing (SIC 165)	2	1	2	1	3	1	9	2	2	22
Chartered Banks/Trust (SIC 701)	23	3	65	1	0	0	0	0	2	95
Insurance (SIC 721)	9	3	35	41	0	0	0	0	4	93
Telecomm. & Cable (SIC 544,545)	5	4	17	1	0	0	1	0	12	40
Trade (SIC 631,642)	5	1	66	84	0	0	3	7	29	195
Comp, Mgt Consult (SIC 853,867)	6	9	8	1	0	0	1	0	2	28
Public Admin (SIC 909,931,951)	47	22	80	1	0	1	4	1	94	250
Subtotal	113	58	303	135	26	47	57	18	168	926
Other Industries	201	103	511	269	126	90	308	74	1,567	3,248
Total Industries	314	161	814	404	152	137	365	92	1,735	4,174
Selected Ind. as a % of Total Ind. by Occ.	36%	36%	37%	33%	17%	34%	16%	20%	10%	22%

All figures rounded in thousands
Source: Statistics Canada, 1981 Census Data (1971 Definitions)

5.0 SUMMARY

Over the next ten years a large number of new and emerging technologies will be introduced and applied in Ontario. Four major groups of new technologies are expected to diffuse rapidly and have been identified as having significant potential employment impacts. These are:

- o Office Automation Technology
- o Telecommunications Technology
- o Computer-Based Technology
- o Advanced Manufacturing Technology

Eight major occupational groups have been identified as being occupations on which the impacts of these technologies should be particularly studied. These include:

- o Managerial, Administrative and related Occupations
- o Natural Sciences, Engineering and Mathematics Occupations
- o Clerical and related Occupations
- o Sales Occupations
- o Processing Occupations
- o Machining and related Occupations
- o Product Fabricating, Assembling and Repairing Occupations
- o Materials Handling and related Occupations

The industry sectors with the largest share of the identified occupational groups are:

- o Primary Metal and Metal Fabricating
- o Motor Vehicles and Parts
- o Machinery and Other Transportation Equipment
- o Electrical Products

- o Chemical, Rubber and Petroleum
- o Communication
- o Trade
- o Finance, Insurance and Real Estate
- o Communities, Business and Personal Services
- o Public Administration

Since these industry sectors are very broad, and in some cases contain quite different types of industries at the 3-digit Standard Industrial Classification level, Twenty-two 3-digit SIC code industries were selected. These are:

Iron and Steel Mills (SIC 291)
Metal Stamping, Pressing and Coating (SIC 304)
Hardware, Tool and Cutlery Manufactures (SIC 306)
Miscellaneous Metal Fabricating (SIC 309)
Miscellaneous Machinery and Equipment Manufacturers (SIC 315)
Office and Store Machinery Manufacturers (SIC 318)
Aircraft and Aircraft Parts Manufacturers (SIC 321)
Communications Equipment Manufacturers (SIC 335)
Plastics Fabricating (SIC 165)
Telephone systems (SIC 544)
Telegraph and Cable systems (SIC 545)
Retail Food Stores (SIC 631)
General Merchandising Stores (SIC 642)
Chartered Banks and Trust Companies (SIC 701)
Life Insurance Companies and General Life Insurance Companies (SIC 721)
Insurance Brokers (SIC 735)
Computer Service Industry (SIC 853)
Management and Business Consultants (SIC 867)
Federal Government (SIC 909)
Provincial Government (SIC 931)
Local Government (SIC 951)

This identification of industries, occupations and technologies was used to target the Task Force's field research. The results of these survey activities are reported in Appendices 4-18 to the Task Force's final report.

APPENDIX A
2-DIGIT OCCUPATIONAL GROUPS
CANADIAN CLASSIFICATION AND DICTIONARY OF OCCUPATIONS, 1971

11	Managerial, Administrative and Related Occupations
21	Occupations in Natural Sciences, Engineering and Mathematics
23	Occupations in Social Sciences and Related Fields
25	Occupations in Religion
27	Teaching and Related Occupations
31	Occupations in Medicine and Health
33	Artistic, Literary, Performing Arts and Related Occupations
37	Occupations in Sport and Recreation
41	Clerical and Related Occupations
51	Sales Occupations
61	Service Occupations
71	Farming, Horticultural and Animal-Husbandry Occupations
73	Fishing, Hunting, Trapping and Related Occupations
75	Forestry and Logging Occupations
77	Mining and Quarrying Including Oil and Gas Field Occupations
81/82	Processing Occupations
83	Machining and Related Occupations
85	Product Fabricating, Assembling and Repairing Occupations
87	Construction Trades Occupations
91	Transport Equipment Operating Occupations
93	Material-Handling and Related Occupations, n.e.c.
95	Other Crafts and Equipment Operating Occupations
99	Occupations Not Elsewhere Classified

APPENDIX B
INDUSTRY SECTOR DEFINITIONS BY 3-DIGIT STANDARD INDUSTRIAL CLASSIFICATIONS (SIC)

Industrial Sector		1970 S.I.C.
1.	Agricultural, Fishing & Trapping	001-021,041-047
2.	Forestry	031-039
3.	Mineral Fuel Mines & Wells	061,064
4.	Other Mines & Quarries	051-059,071-099
5.	Food, Feed, Beverage & Tobacco	101-153
6.	Textile & Clothing	181-249
7.	Wood & Furniture	251-268
8.	Paper & Allied Industries	271-289
9.	Primary Metal & Metal Fabricating	291-309
10.	Motor Vehicles & Parts	323-325
11.	Machinery & Other Transportation	311-321,326-329
12.	Electrical Products	331-339
13.	Chemical, Rubber & Petroleum	162-165,365-379
14.	Non-metallic Mineral Products	351-359
15.	Other Manufacturing Industries	172-179,391-399
16.	Construction	404-421
17.	Electric Power & Gas Utilities	572-579
18.	Transportation & Storage	501-527
19.	Communication	543-548
20.	Trade	602-699
21.	Finance, Insurance & Real Estate	701-737
22.	Communities, Business & Personal Services	801-899
23.	Public Administration	902-991

APPENDIX C

TERMS OF REFERENCE
FOR
THREE PROJECTS REGARDING THE MANPOWER AND EMPLOYMENT IMPLICATIONS OF NEW TECHNOLOGIES IN SELECTED ONTARIO INDUSTRIES TO 1995

Project A: Manpower and Employment Implications of New Technologies in Selected Manufacturing Industries in Ontario to 1995 (Tender #: TF 84/A)

Project B: Manpower and Employment Implications of New Technologies in the Finance, Insurance, and Public Administration Industries in Ontario to 1995 (Tender #: TF 84/B)

Project C: Manpower and Employment Implications of New Technologies in the Communications, Trade, and Other Services Industries in Ontario to 1995 (Tender #: TF 84/C)

July, 1984

1.0 BACKGROUND

1.1 A review of world-wide publications concerning the manpower and employment implications of new technologies reveals a wide range of opinions on the subject. The spectrum of debate is widely spread between the optimists, pessimists, and those who take a neutral stand. There is little doubt amongst observers that new technologies will increasingly be applied over the years ahead, and that they will have different implications, both positive and negative, on various industry sectors and occupational groups. What is lacking is a significant knowledge base regarding the nature and extent of the manpower and employment implications of new technologies.

1.2 The Ontario Task Force on Employment and New Technology, co-chaired by Messrs. William Boggs and Robert White, has been established to consider this important issue. The mandate of the Task Force is to assess the nature and extent of the manpower and employment implications of new technologies as the same may be introduced in Ontario over the next decade.

1.3 The Task Force has identified four key groups of related technologies that are expected to have widespread commercial application and significant direct and indirect manpower and employment implications in Ontario over the next 10 years. These are:

- computer technology;
- office automation technology;
- advanced manufacturing technology;
- telecommunications technology.

1.4 The Task Force wishes to examine the impact of these technologies on eight major occupational groups. These are:

- Managerial, Administrative and Related Occupations;
- Natural Sciences, Engineering and Mathematics Occupations;

- Clerical and Related Occupations;
- Sales Occupations;
- Processing Occupations;
- Machining and Related Occupations;
- Product Fabricating, Assembling and Repairing Occupations; and
- Materials Handling and Related Occupations.

1.5 An analysis has been conducted to identify the industry sectors in Ontario which contain the largest employment share of those occupations listed. These are:

- Primary Metal and Metal Fabricating;
- Motor Vehicles and Parts;
- Machinery and Other Transportation;
- Electrical Products;
- Chemical, Rubber and Petroleum;
- Communications;
- Trade;
- Finance, Insurance, and Real Estate;
- Communities, Business amd Personal Services; and
- Public Administration.

1.6 An additional sub-analysis has also been conducted to identify, within each industry sector, particular industries which contain significant employment shares of the occupations of interest, and which are sufficiently clearly focused so as to generate useful information. (These particular industries are presented later.)

1.7 The Task Force now wishes to conduct three separate research projects, in which related industries are grouped together, and which examine the nature and extent of the impacts of new technologies on the occupational groups earlier identified.

2.0 OBJECTIVE OF THE STUDY

The main objective of the study is to assess the nature and extent of the manpower and employment implications of new technologies on particular occupational groups in selected industries.

3.0 SELECTED INDUSTRIES

Nine major industry sectors have been selected for examination in this study. (The Motor Vehicles and Parts sector, although identified earlier in Section 1.5, will not be part of this study and will be separately dealt with elsewhere). Within each sector, specific industries are also selected. These selected industries are grouped into three separate, but related projects for the purposes of organizing and administering the study.

3.1 Project A: Manpower and Employment Implications of New Technologies in Selected Manufacturing Industries in Ontario to 1995 (Tender #: TF 84/A)

This project is concerned with the manpower and employment implications for particular occupations of new technologies applied in selected manufacturing industries, with focus on those technologies that automate production, and includes the study of the following particular manufacturing industries grouped under four industry sector headings . Special attention will be paid to the following major occupational groups: managerial, administrative and related occupations; natural sciences, engineering and mathematics occupations; processing occupations; machining and related occupations; product fabricating, assembling and repairing occupations; materials handling and related occupations.

Primary Metal and Metal Fabricating

- Iron and Steel Industry (SIC 291)
- Metal Fabricating Industry (SIC 304,306,309)

Machinery and Aircraft

- Machinery and Equipment Industry (SIC 315)
- Aircraft and Aircraft Parts Industry (SIC 321)

Electrical and Electronics Products

- Communications Equipment Industry (SIC 335)
- Office, Store and Business Machine Industry (SIC 318)

Chemical and Plastics

- Plastics Processing Industry (SIC 165)

3.2 Project B: Manpower and Employment Implications of New Technologies in Finance, Insurance, and Public Administration Industries in Ontario to 1995 (Tender #: TF 84/B)

This project is concerned with the manpower and employment implications for particular occupations of new technologies applied in the following two industry sectors, with concentration on the particular industries indicated. Special attention will be paid to the folowing major occupational groups: managerial, administrative and related occupations; natural sciences, engineering and mathematics occupations; clerical and related occupations; sales occupations.

Finance and Insurance

- Chartered Banks and Trust Companies (SIC 701)
- Insurance Industry (SIC 721, 735)

Public Administration

- Government Service Industries (SIC 909,931,951)

3.3 Project C: Manpower and Employment Implications of New Technologies in Communications, Trade, and Other Service Industries in Ontario to 1995 (Tender #: TF 84/C)

This project is concerned with the manpower and employment implications for particular occupations of new technologies applied in the following three industry sectors, with concentration on the particular industries indicated. Special attention will be paid to the following major occupational groups: managerial, administrative and related occupations; natural sciences, engineering and mathematics occupations; clerical and related occupations; sales occupations.

Communications

- Telecommunications and Cable Industry (SIC 544,545)
- Post Office (SIC 548)

Trade

- Retail Trade Industry (SIC 631,642)

Communities, Business & Personal Services

- Computer, Management and Business Consulting Services (SIC 853,867)

4.0 METHODOLOGY

In view of the complexity of the study, a combination of techniques such as desk research, expert consultation, and in-depth interviews with company and worker representatives are deemed to be most appropriate to gather the required information. This methodology will also ensure the collection of first-hand, up-to-date quantitative as well as qualitative information.

5.0 TASKS TO BE PERFORMED

The consultant will be expected to perform the following tasks and prepare the following intermediate and final reports:

5.1 Desk Research

For each industry under study, intensive desk research will be conducted to identify and collect various kinds of quantitative information, wherever possible, regarding trends over the past ten years experienced by that industry. These will include: aggregate industry output and employment, employment by occupation, and investment trends, together with qualitative information regarding past adoption of new technologies and related adjustments of the workforce. (Employment data should be presented with a breakdown by sex.)

An information base established by the Task Force research staff containing part of the required data will be made available to the Suppliers.

An Intermediate Report which presents this historical analysis is due in two months after the commencement of the project.

5.2 Expert Consultation

For each industry under study, conduct interviews and/or discussion panels with industry experts:

- to assess both the current and next decade's aggregate trends on investment, industry output and employment, and diffusion rates of new technologies;

- to provide expert opinion input to the questionnaire which will be used to collect pertinent information (in 5.5); and

. to indentify the firms to which the questionnaire should be directed (see 5.4).

5.3 Develop the Questionnaire

For each industry under study, develop a structured questionnaire to collect pertinent information from company and worker representatives (see 5.5).

5.4 Select a Representative Sample

For each industry under study, select a sample of firms with good representation of the following:

- industry groups
- employment-size groups
- types of technologies and occupations under study

An Intermediate Report which presents the findings of expert consultation, the proposed questionnaire, and a list of firms to be surveyed is due as soon as possible and in no case longer than two months after the commencement of the project.

5.5 Field Work

For each industry under study, conduct in-depth personal interviews with appropriate company and worker representatives who would have good knowledge of the likely manpower and employment implications of new technologies in the workplace.

An Intermediate Report is due in five months summarizing the interview findings, and including any other additional comments from the respondents.

5.6 Analysis and Preparation of Final Report

For each industry under study, analyse all pertinent information collected and prepare a final report to be submitted to the Task Force. Additional expert consultation with industry experts regarding the findings may be required to check the validity and accuracy of the data.

Final reports are due by February 28, 1985.

6.0 INFORMATION REQUIREMENTS

The following information will be provided for each of the industries under study:

6.1 Provide quantitative information regarding historical trends experienced over the past ten years by that industry, including: aggregate output and employment, employment by occupation, investment trends, and including qualitative information regarding past adoption of new technologies and related adjustments of the workforce (employment data should be presented with a breakdown by sex).

6.2 Identify those particular new technologies from the list identified in Section 1.3 which are currently being adopted, or likely to be adopted, and which are expected to have significant manpower and employment implications over the 1985-1995 period.

6.3 For each of the new technologies identified, provide the current rate of adoption and the expected future rate of adoption in the industry over the 1985-95 period.

6.4 For each industry, provide over the 1985-1995 period estimates of the future aggregate industry output and employment, investment trends, and employment by occupation for those major occupational groups specified in Section 3.1,3.2,3.3, respectively. (The estimates

of future occupational employment will include changes resulting from shifts in estimated demand for the industry's output, and changes resulting from the adoption of new technologies.)

6.5 From the major occupational groups considered in Section 6.4, identify those occupations on a more detailed occupational level which are particularly affected by the new technologies identified in Section 6.2.

6.6 For each of the occupations identified in Section 6.5, assess the extent to which these occupations are likely to be affectd over the 1985-1995 period.

6.7 For each of the occupations identified in Section 6.5, examine the changes in skill requirements of these affected occupations and their resultant training implications.

6.8 Identify and examine other pertinent labour market developments associated with those occupations identified as being particularly affected by the adoption of new technologies, including: changes in sources of supply, changes in entry requirements, changes in methods of training and retraining, and changes in organisational arrangements concerning human resources planning.

7.0 DATA COLLECTION STANDARD

In order to provide complementary and yet consistent information for the industry studies, the following guidelines with respect to the data collection standard are suggested:

- Historical data should be presented, whenever available, for the past ten years.

- All estimates of future manpower and employment implications should cover the reference time period, i.e. 1985-1995, with a breakdown of estimates by two periods, 1985-1990 and 1990-1995.

- All historical and projected data should be differentiated between the sample firms surveyed and that of the estimated overall industry total, and the assumptions used for the projections and estimates should always be explicitly stated.

- If data on future employment and occupations are not directly available, the average growth rates (in percentages) should be sought, and estimations made. Whenever appropriate, qualitative information should be collected to supplement the quantitative analysis.

- For data collection and analysis, every effort should be made to use the coding system of the 1970 Standard Industrial classification (SIC) for different industries, and the 1971 Canadian Classification and Dictionary of Occupations (CCDO) for various occupations ranging from 2-digit to 7-digit levels.

8.0 REQUIRED STRUCTURE OF FINAL REPORTS

Separate final reports are required for each of the industries under study. Each report must conform to the following format:

Chapter 1: Executive Summary; scope of the study; methodology.

Chapter 2: Background of the industry under study, including aggregate industry output and employment, employment by occupation, investment trends, and other information regarding past adoption of new technologies and related adjustments of the workforce.

Chapter 3: Identification of new technologies expected to be applied over the 1985-95 period; current rate of adoption; expected future rate of adoption.

Chapter 4: Industry Outlook to 1995.
- aggregate industry output and employment;
- investment trends;
- employment by major occupational group.

Chapter 5: Occupational Employment Outlook to 1995.

- occupations particularly affected by the adoption of new technologies;
- the extent to which these occupations are affected;
- changes in skill requirements for the affected occupations.

Chapter 6: Associated Labour Market Developments

- changes in sources of supply;
- changes in entry requirements;
- changes in methods of training and retraining;
- changes in organisational arrangements concerning human resources planning.

9.0 SCHEDULE

The final report must be completed and submitted in six months from the commencement of the project:

Expected starting date: September 4, 1984

Completion date: February 28, 1985

Intermediate reports on desk research and expert consultation are due October 30, 1984. Intermediate report on field work is due January 31, 1985. Final report is due February 28, 1985.

10.0 REPORTING

The Supplier will report to the Research Director of the Ontario Task Force on Employment and New Technology, who may assign staff members of the Task Force to provide on-going direction to the Supplier. If requested, the Supplier must be prepared to make presentations to the Task Force regarding the findings of the study.

11.0 RESEARCH SUPPORT

The Supplier will have access to a computerized bibliography on the employment implications of new technologies, which comprises approximately 1,100 items of selected documents on the subject. The bibliography can be searched by author, title, geographic locations, dates, and different topics listed under industries, technology and issues.

FINAL REPORT AND APPENDICES OF THE ONTARIO TASK FORCE ON EMPLOYMENT AND NEW TECHNOLOGY

Final Report: **Employment and New Technology**

Appendices:

1. Labour Market Trends in Ontario, 1950-1980.
2. Occupational Employment Trends in Ontario, 1971-1981.
3. Emerging New Technology, 1985-1995: Framework for a Survey of Firms.
4. Employment and New Technology in Ontario's Manufacturing Sector: A Summary of Selected Industries.
5. Employment and New Technology in the Iron and Steel Industry.
6. Employment and New Technology in the Metal Fabricating Industry.
7. Employment and New Technology in the Machinery and Equipment Industry.
8. Employment and New Technology in the Airdraft and Aircraft Parts Industry.
9. Employment and New Technology in the Communications Equipment Industry.
10. Employment and New Technology in the Office, Store and Business Machine Industry.
11. Employment and New Technology in the Plastic Processing Industry.
12. Employment and New Technology in Ontario's Service Sector: A Summary of Selected Industries.
13. Employment and New Technology in the Chartered Banks and Trust Industry.
14. Employment and New Technology in the Insurance Industry.
15. Employment and New Technology in the Government Services Industry.
16. Employment and New Technology in the Telecommunications Industry.
17. Employment and New Technology in the Retail Trade Industry.
18. Employment and New Technology in the Computer Services and Management Industry.
19. Industry-Sector and Occupational Employment in Ontario, 1985-1995.
20. Technological Change, Productivity, and Employment: Studies of the Overall Economy.


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